PCT/EP2004/051602

26 JUL 2004

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Patentanmeldung Nr. Patent application No. Demande de brevet n°

03077544.9

PRIORITY DOCUMENT
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Anmeldung Nr:
Application no.: 03077544.9
Demande no:

Anmeldetag:
Date of filing: 11.08.03
Date de dépôt:

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
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Method for installing a double ended distributed sensing fiber optical assembly within a guide conduit

In Anspruch genommene Prioriät(en) / Priority(ies) claimed /Priorité(s) revendiquée(s)
Staat/Tag/Aktenzeichen/State/Date/File no./Pays/Date/Numéro de dépôt:

Internationale Patentklassifikation/International Patent Classification/
Classification internationale des brevets:

E21B/

Am Anmeldetag benannte Vertragstaaten/Contracting states designated at date of filing/Etats contractants désignées lors du dépôt:

AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LU MC NL
PT RO SE SI SK TR LI

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11 08. 2003

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TS 6439 EPC

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METHOD FOR INSTALLING A DOUBLE ENDED DISTRIBUTED SENSING FIBER OPTICAL ASSEMBLY WITHIN A GUIDE CONDUIT

BACKGROUND OF THE INVENTION

The invention relates to a method of installing a double ended distributed optical fiber assembly within a guide conduit.

Such a method is known from European patent application EP 0424120, Japanese patent application JP 2001124529A and from International patent application WO 00/49273.

In the method known from Japanese patent application JP 2001125529A a distributed strain and displacement sensing fiber optical cable is bent into a U-shape and lowered into a underground borehole by means of a weight suspended from the U-folded nose section of the optical fiber.

In the method known from International patent application WO 00/49273 a U-folded distributed temperature sensing fiber optical cable is inserted into a coiled tubing within an underground borehole by connecting the U-folded mid-section of the fiber optical cable to a plug which is bull headed by pumping fluid though the tubing to carry the plug and the fiber optical cable to the bottom of the well.

The known U-shaped, double ended, distributed sensing fiber optical assemblies are inserted into guide conduits that are formed by a well casing and coiled well tubing having an internal width which is typically several

centimeters and they are not configured to be installed in small diameter guide conduits.

An object of the present invention is to provide a method for installing a double ended distributed sensing fiber optical assembly within a small diameter guide conduit.

SUMMARY OF THE INVENTION

The method according to the invention for installing a double ended distributed sensing optical fiber assembly within a guide conduit comprises:

- providing a nose section, which interconnects the proximal ends of two sections of distributed sensing fiber optical cable such that light transmitted along the length of one section of fiber optical cable is transmitted via the nose section into the other section of fiber optical cable;
- inserting the nose section into the guide conduit such that the nose section moves through the guide conduit ahead of said two sections of distributed sensing fiber optical cable that are interconnected thereby;
- connecting the distal ends of the sections of distributed sensing fiber optical cable to a light transmission and receiving unit; and
- wherein the nose section has an outer width (W) which is less than 1 cm.

In one embodiment of the method according to the invention the nose section and two sections of distributed sensing fiber optical cable interconnected thereby are formed from a single fiber optical cable, which is bent into a U-shaped configuration in the region of the nose section and the fiber optical cable is stretched in said region such that the fiber optical cable has a smaller width in the region of the nose

section than in most other parts of the fiber optical cable.

In such case it is preferred that the fiber optical cable is heated when it is stretched and the bent section of stretched fiber optical cable is embedded in a nose-shaped body of material having a lower light reflection index than the stretched fiber optical cable embedded therein and that said nose shaped body has a substantially cylindrical shape and an outer diameter less than 3 mm. A suitable method for bending a fiber optical cable into a U-shaped configuration is disclosed in US patent 5,138,676.

In an alternative embodiment of the method according to the invention the two sections of distributed sensing fiber optical cable are interconnected by a nose section which comprises a light reflecting element, such as a mirror, which is configured to transmit light emitted from a proximal end of one section of distributed sensing fiber optical cable into a proximal end of the other section of distributed sensing fiber optical cable.

In both embodiments of the method according to the invention it is preferred that the light transmitting and receiving unit is configured to transmit light pulses alternatingly into each distal end of each of said two sections of distributed sensing fiber optical cable and to acquire distributed sensing data from light backscattered from different points along the length of the fiber optical cables to the distal end into which the light pulses are transmitted.

The distributed sensing fiber optical assembly installed by the method according to the invention may be configured as a distributed temperature and/or distributed pressure sensor assembly, and each section of

distributed sensing fiber optical cable may pass through a reference region in which the fiber optical cable is exposed to a known temperature and/or hydraulic pressure. In such case said reference region may be formed by a chamber in which the temperature and pressure are monitored, in which chamber a selected length of each section of distributed sensing optical fiber is coiled.

Suitably, the nose section and at least a substantial part of the distributed sensing fiber optical cables interconnected thereby are inserted into the guide conduit by pumping a fluid from one end towards another end of the guide conduit.

The guide conduit may be installed within or in the vicinity of an elongate fluid transfer flowline, such as an underground inflow region of an oil and/or gas production well.

The invention also relates to a method of producing oil and/or gas, wherein the temperature and/or pressure of fluids flowing through at least part of an inflow region of an oil and/or gas production well is monitored by a double ended distributed sensing fiber optical assembly which is installed in accordance with the method according to the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Several embodiments of the method according to the invention will be described in more detail and by way of example with reference to the accompanying drawings, in which:

Fig. 1 depicts a guide conduit which contains a double ended distributed sensing fiber optical cable assembly that has a nose section in which a U-folded section of the optical fiber is embedded; and

Fig. 2 depicts a guide conduit which contains a double ended distributed sensing fiber optical cable assembly that has a nose section in which light emitted from one fiber optical cable section is reflected into another fiber optical cable section.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

Fig.1 depicts an elongate guide conduit 1, which contains a double ended fiber optical sensing assembly 2 having a nose section 3 in which a U-folded nose portion 4C of an optical fiber is embedded. The U-folded nose portion 4C interconnects two elongate sections 4A and 4B of the optical fiber. The U-folded nose portion 4C is heated to a temperature above 1000 degrees Celsius and stretched during the bending process, whereupon the red-hot bent U-folded nose portion is embedded in a body 5 of material having a lower index of reflection than the U-folded nose portion 4C of the optical fiber 4, thereby creating optical continuity in the U-folded nose portion 4C. A suitable method for bending a fiber optical cable into a U-shaped configuration is disclosed in US patent 5,138,676. The nose section 3 comprises an impact resistant outer coating 6 and has a generally cylindrical shape. The outer width of the nose section 3 has an outer width W which is less than 1 cm. In a preferred embodiment the method of the present invention the guide conduit 1 has an internal width less than 1 cm and the nose section 3 has an outer width less than 5 mm. In a particularly preferred embodiment of the method according to the invention the guide conduit 1 has an internal width less than 5 mm and the nose section 3 has an outer width W less than 3 mm. The small internal and external width of the guide conduit 1 generate a distributed

sensing assembly which is compact and non-intrusive and which can be easily inserted into narrow passageways, such as hydraulic power and control conduits, in an underground well for the production of oil and/or gas.

The elongate sections 4A and 4B of the fiber optical cable 4 comprise a pair of proximal ends 4D and 4E that are interconnected by the U-shaped nose portion 4C and a pair of distal ends 4F and 4G. Each distal end 4F and 4G provides an end of the double ended distributed sensing optical fiber assembly 2. Each distal end 4F and 4G may be connected to a light pulse generation and receiving unit 7 which is equipped with two light sources 8A and/or 8B, which are configured to transmit alternatingly pulsed or simultaneously pulsed and continuous wave laser light signals 9A and 9B into the elongate sections 4A and 4B of the fiber optical cable. The unit 7 also provides a reference chamber in which the upper parts of the elongate sections 4A and 4B are exposed to a known temperature and/or pressure. By using a double ended fiber optical temperature and/or pressure sensing assembly 2 light pulses 9A and 9B can be directed in both ways though the assembly, which enables to compensate for any attenuation of the light pulses 9A and 9B as they travel along the length of the fiber optical cable 4 and which eliminates the need for the use of a downhole pressure and/or temperature reference sensor, which is required for the conventional single ended distributed pressure and/or temperature sensing (DPS/DTS) fiber optical assemblies.

Fig.2 depicts an alternative embodiment of the method according to the invention, wherein the proximal ends 21A and 22A of two distributed sensing (DPS and/or DTS) fiber optical cables 21 and 22 are interconnected by a nose

section 23 which comprises a mirror 24 and lenses 25 and 26, which reflect light from the first fiber optical cable 21 into the second fiber optical cable 22 and vice versa as illustrated by the dotted lines 27. The proximal ends of the fiber optical cables 21 and 22 are encapsulated within the nose section 23, which has an outer width W less than 1 cm, preferably less than 5 mm. The nose section is suspended within a guide conduit 28 having an internal diameter which is less than 2 cm, preferably less than 1 cm.

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C L A I M S

1. A method of installing a double ended distributed sensing optical fiber assembly within a guide conduit, the method comprising:

- providing a nose section, which interconnects the proximal ends of two sections of distributed sensing fiber optical cable such that light transmitted along the length of one section of fiber optical cable is transmitted via the nose section into the other section of fiber optical cable;
- inserting the nose section into the guide conduit such that the nose section moves through the guide conduit ahead of said two sections of distributed sensing fiber optical cable that are interconnected thereby;
- connecting the distal ends of the sections of distributed sensing fiber optical cable to a light transmission and receiving unit; and
- wherein the nose section has an outer width (W) which is less than 1 cm.

2. The method of claim 1, wherein the nose section has an outer width W which is less than 5 mm and the guide conduit has an internal width which is less than 10 mm.

3. The method of claim 1, wherein the nose section and two sections of distributed sensing fiber optical cable interconnected thereby are formed from a single fiber optical cable, which is bent into a U-shaped configuration in the region of the nose section and the fiber optical cable is stretched in said region such that the fiber optical cable has a smaller width in the region

of the nose section than in most other parts of the fiber optical cable.

4. The method of claim 3, wherein the fiber optical cable is heated when it is stretched and the bent section of stretched fiber optical cable is embedded in a nose-shaped body of material having a lower light reflection index than the stretched fiber optical cable embedded therein.

5. The method of claim 4, wherein said nose shaped body has a substantially cylindrical shape and an outer diameter less than 3 mm.

6. The method of claim 1 or 2, wherein the two sections of distributed sensing fiber optical cable are interconnected by a nose section which comprises a light reflecting element, such as a mirror, which is configured to transmit light emitted from a proximal end of one section of distributed sensing fiber optical cable into a proximal end of the other section of distributed sensing fiber optical cable.

7. The method of any preceding claim, wherein the light transmitting and receiving unit is configured to transmit light pulses or pulsed and continuous waves alternatingly or simultaneously into each distal end of each of said two sections of distributed sensing fiber optical cable and to acquire distributed sensing data from light backscattered from different points along the length of the two sections of fiber optical cable to the distal end into which the light pulses are transmitted.

8. The method of claim 7, wherein the distributed sensing fiber optical assembly is configured as a distributed temperature and/or distributed pressure sensor assembly, and wherein each section of distributed sensing fiber optical cable passes through a reference

region in which the fiber optical cable is exposed to a known temperature and/or hydraulic pressure.

9. The method of claim 8, wherein said reference region is formed by a chamber in which the temperature and pressure are monitored, in which chamber a selected length of each section of distributed sensing optical fiber is coiled.

10. The method of claim 1, wherein the nose section and at least a substantial part of the distributed sensing fiber optical cables interconnected thereby are inserted into the guide conduit by pumping a fluid from one end towards another end of the guide conduit.

11. The method of claim 1, wherein the guide conduit is installed within or in the vicinity of an elongate fluid transfer flowline.

12. The method of claim 11, wherein the fluid transfer flowline is an underground inflow region of an oil and/or gas production well.

13. A method of producing oil and/or gas, wherein the temperature and/or pressure of fluids flowing through at least part of an inflow region of an oil and/or gas production well is monitored by a distributed sensing fiber optical assembly which is installed in accordance with the method according to claim 12.

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ABSTRACT

METHOD FOR INSTALLING A DOUBLE ENDED DISTRIBUTED SENSING FIBER OPTICAL ASSEMBLY WITHIN A GUIDE CONDUIT

A method of installing a double ended distributed sensing optical fiber assembly (2) within a guide conduit (1), such as a small diameter control line in an underground borehole, comprises:

- providing a nose section (3) having an outer width (W) which is less than 1 cm, preferably less than 5 mm, which nose section (3) interconnects the proximal ends (4C and 4D) of two sections (4A and 4B) of distributed sensing fiber optical cable such that light transmitted along the length of one section of fiber optical cable (4A)is transmitted via the nose section (3) into the other section (4B) of fiber optical cable;
- inserting the nose section (3) into the guide conduit (1) such that the nose section (3) moves through the guide conduit (1) ahead of said two sections (4A and 4B) of distributed sensing fiber optical cable that are interconnected thereby; and
- connecting the distal ends (4E and 4F) of the sections of distributed sensing fiber optical cable to a light transmission and receiving unit (7) which is configured to convert the light spectra backscattered from different points of the fiber optical cable into distributed temperature, pressure and/or other physical data.

(Fig. 1)

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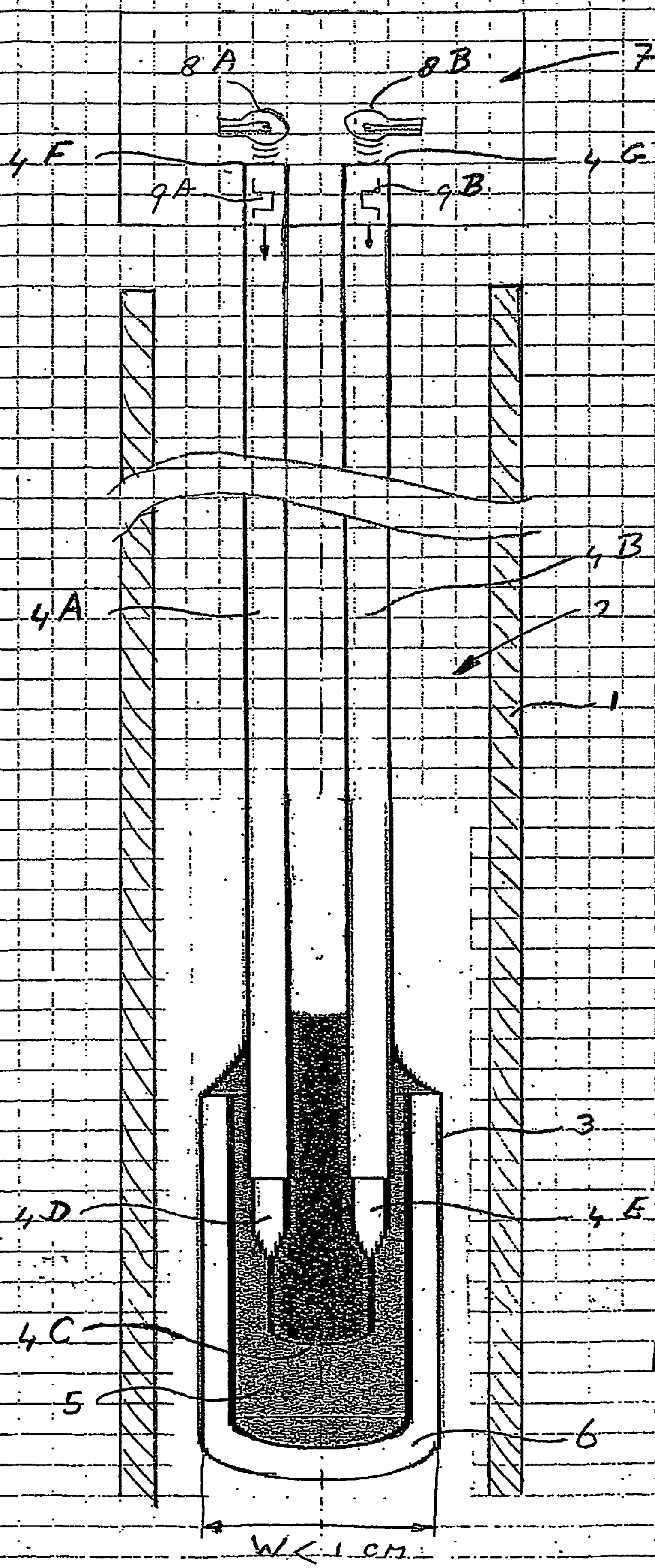

FIG. 1

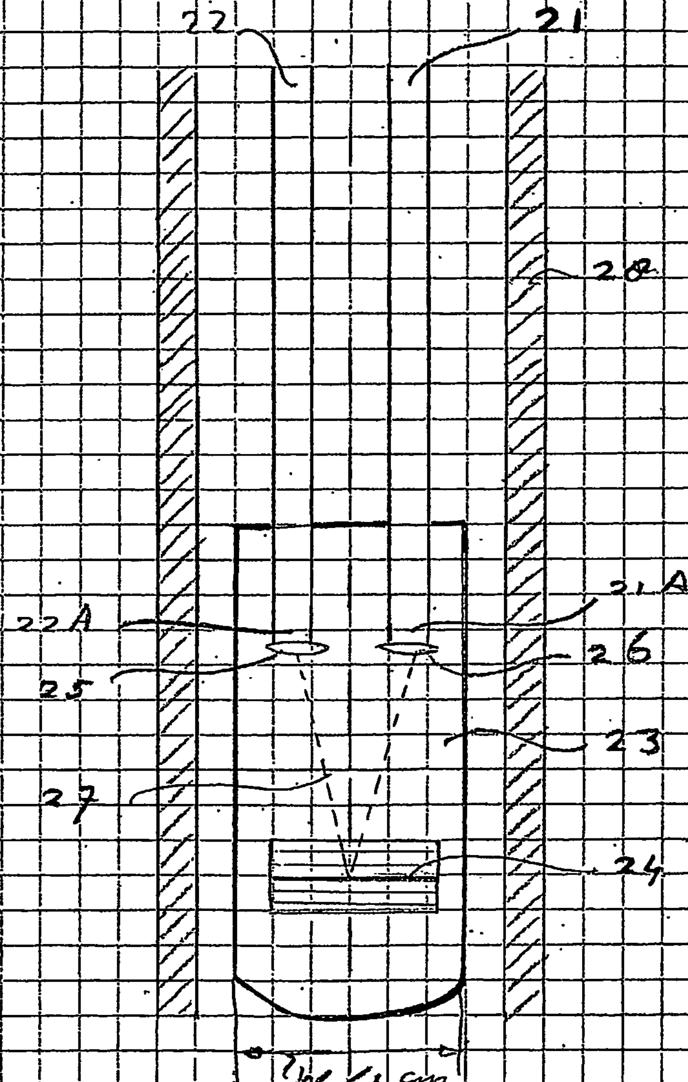

FIG.2